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THERE IS NO THIRD BODY IN THE ECLIPSING BINARY SYSTEM HS HERCULIS

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HS Herculis (HD 174714, HIP 92478, BD+24°3552, $\alpha_{2000} = 18^{\rm h}50^{\rm m}50^{\rm s}$, $\delta_{2000} = 24°43'12''$) is a detached eclipsing binary system with an Algol-type light curve and period of $1\overset{\rm d}{.}637434$. It contains a B5-type primary and an A4-type secondary components. The variability of HS Herculis was first discovered by Martynov (1940) in 1934 and independently by Jacchia (1940) in 1940. The first spectroscopic study was published by Cesco & Sahade (1945). Hall & Hubbard (1971) published the first period analysis of HS Herculis and they found an apsidal motion with a period of 15.5 years in the system. Martynov & Lavrov (1972), Todoran (1992) and Khaliullina & Khaliullin (1992) confirmed the apsidal motion and computed the values of 110-130 years, 60 years, and 92 years for the period, respectively. On the basis of the same data as Todoran's, Bastian (1993) rejected the apsidal motion hypothesis and suggested a light-time effect with a period of 60 years. Todoran & Agerer (1994) confirmed the apsidal motion and rejected any assumption on the presence of a third body. Finally, Wolf et al. (2002) determined a period of 78 years for the apsidal motion and, in addition to that, they proposed a light-time effect with a period of about 85 years in the system.

The observations of HS Her were made with the 30 cm Maksutov telescope (equipped with a SSP-5A photometer containing a side-on R1414 Hamamatsu photomultiplier) of the Ankara University Observatory in 2002 and 2003. The observations are carried out using standard Johnson U, B and V filters. HD 343238 (HIP 92624) and HD 343123 (PPM 107921) are used as comparison and check stars, respectively.

New minimum times of HS Herculis are given in Table 1. Note that the standard errors are given in parenthesis.

Table 1. New minimum times of HS Herculis

Min time HJD	Type	Filter	Observers
2452472.3943 (9)	II	UBV	TÇ & ET
2452513.3223 (22)	II	BV	TÇ & ET
2452833.4343 (5)	I	UBV	OA & MY
2452842.4531 (16)	II	UBV	TÇ
2452856.3594 (5)	I	UBV	TÇ & GG

Observers: TÇ: T.Çolak, ET: M.E.Törün, GG: H.G.Gökay, OA: O.Aksu, MY: M.Yılmaz

On the basis of 101 minimum times (including 33 secondary minima), we analyzed the $O-C$ curve of HS Herculis. The corresponding $O-C$ differences refer to the following linear ephemeris:

$$\text{Min I} = \text{HJD } 2452856.3646 + 1\overset{\text{d}}{.}6374341 \text{ E} \quad (1)$$

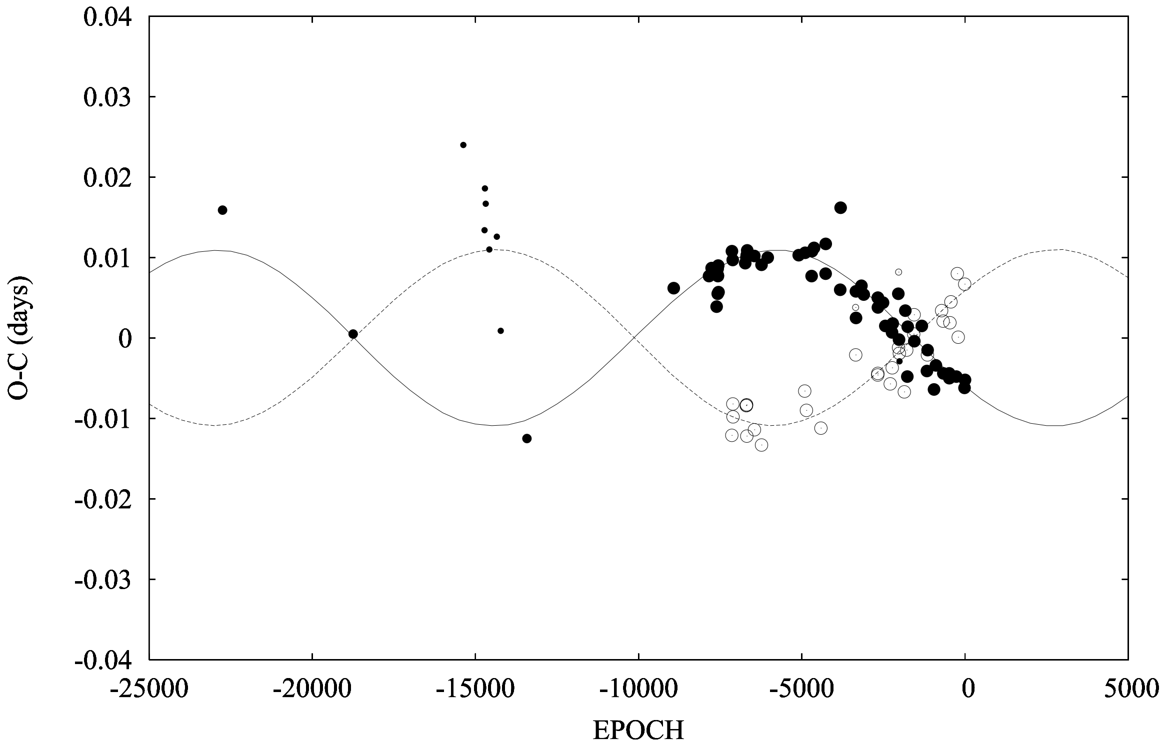

Figure 1. The $O-C$ diagram of HS Herculis.

The $O-C$ values for the minimum times and the $(O-C)_{II}$ residuals from apsidal motion analysis are shown in Fig. 1 and Fig. 2 respectively. Primary and secondary minima are plotted as filled dots and open circles respectively. Larger symbols correspond to more reliable points (CCD, photoelectric and photographic data), smaller symbols correspond to less reliable visual estimates and to some photoelectric observations that have probable systematic errors. The weights used in the calculations are 1.0 for CCD and photoelectric minima, 0.5 for photographic minima and 0.1 for visual estimates. The theoretical fit curves are determined by using the apsidal motion analysis method described by Giménez and García-Pelayo (1983) and on equations revised by Giménez and Bastero (1995). Apsidal motion elements are computed adopting the orbital inclination of $i = 88\overset{\circ}{.}7$ which is derived by Hall & Hubbard (1971) from light curve analysis. The full and dashed curves in Fig. 1 represent the fit curves of the primary and secondary minima, respectively.

All the points except seven minima (which are located between Epoch -15000 and -14000 in Fig. 1 and Fig. 2) correspond to the theoretical apsidal motion curve. It is clear that these seven points could not be represented by the fit curve. However, these minima were obtained from visual observations and they have very low weights in the calculations. Since we know that visual observations have major errors and show very

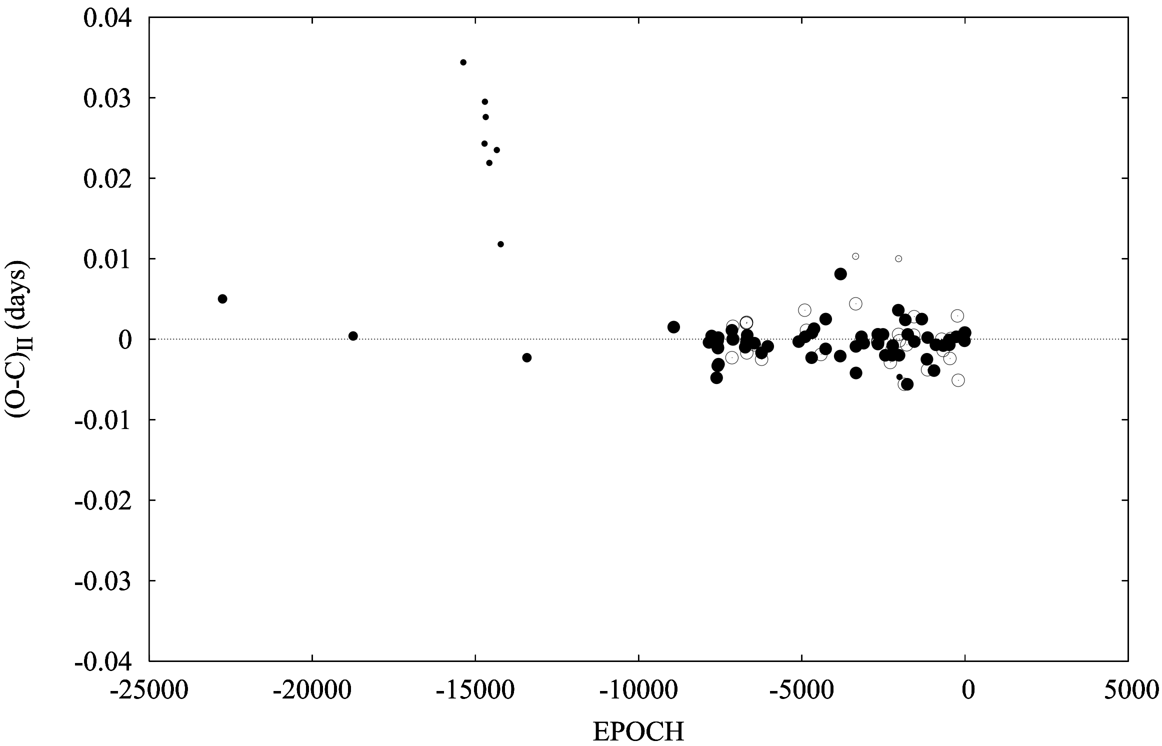

Figure 2. The $(O-C)_{II}$ diagram of HS Herculis.

large scatters in general, in our opinion, it won't be suitable to hypothesize a light-time effect in the system, on the basis of them. Furthermore, the first and second minima not used in previous studies of HS Her, clearly deny a light-time hypothesis. These two minima obtained from photographic observations are relatively more reliable points then the visual estimates. Note that these two minima are published by Jacchia (1940) and Martynov (1985), respectively, and the first minimum time is also available on Dieter Lichtenknecker's database which is maintained by Dr. Walter (Paschke 2004).
As a result we find that the mechanism of the period variability can be only an apsidal motion with a period of about 77 years and there is no evidence for presence of a third body in the system. Our results of apsidal motion analysis are given in Table 2.

Table 2. Apsidal motion parameters of HS Herculis

Parameters	Value
T_0 (HJD)	2452856.3646 ± 0.0002
P_s (days)	1.6374341 ± 0.0000001
e	0.0205 ± 0.0010
ω_0 (deg)	302.5 ± 4.0
$\dot{\omega}$ (deg/cycle)	0.0210 ± 0.0010
P_a (days)	1.6375296 ± 0.0000042
U (years)	76.9 ± 3.4

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